Communication Systems Coursework

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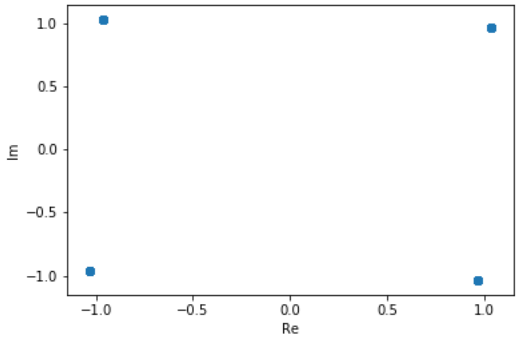
1 Introduction

This report will cover the results of the 7 defined tasks in the coursework. Along with this report is the bare code (QPSK.py). The transmitted message and jamming message are semi-random latin passages generated at *www.lipsum.com*. Respectively the desired message and jamming message are:

> Lorem ipsum dolor sit amet, consectetur adipiscing elit. Suspendisse non orci sem. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos himenaeos. Maecenas tempor et urna sit amet ornare. Maecenas mattis ligula eleifend, ultrices lacus a, pellentesque nisl. Vestibulum tel
>
> Mauris interdum tempor neque, eget ornare erat eleifend luctus. In quis arcu cursus, lobortis leo sit amet, dignissim odio. Mauris molestie vel orci et consequat. Nunc nec sapien eu purus tempor vulputate. Donec in tristique lectus, a interdum orci. Cras rhoncus sapien nec aliquet egestas. Donec ege

2 Task 1

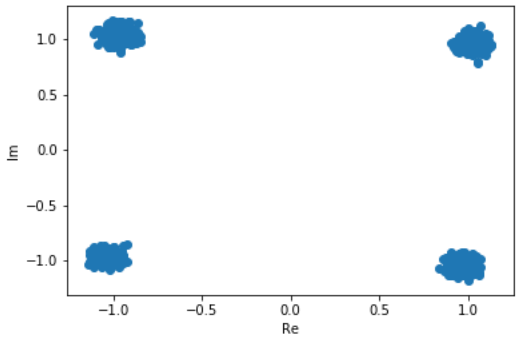
In the absence of noise and a jammer, the transmitted signal is identical to the received signal, therefore this is a test of whether the modulation/demodulation operate correctly.



The constellation diagram shows that all symbols at the output are in exactly the same place. This is exactly as was expected, as there is no behaviour in the channel that would cause the symbols to move.

3 Task 2

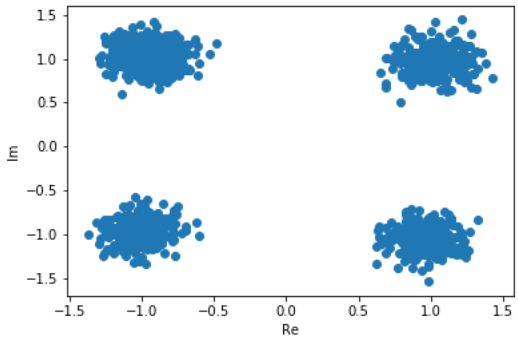
For $SNR_{in} = 30$dB, is is expected that a small amount of variation around each of the symbols will be seen, but as the signal's power is still far greater than that of the noise, no errors should be present.



As was predicted, the constellation at the output shows small clusters of points around the transmitted symbol positions. But the received message is identical to the transmitted one.

4 Task 3

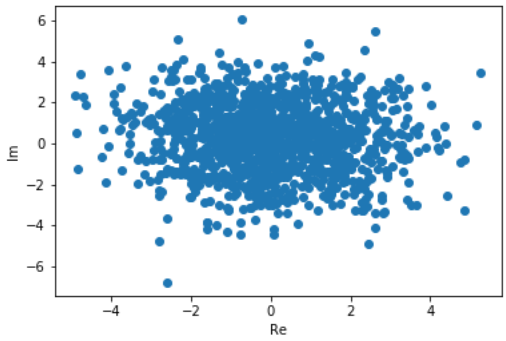
For $SNR_{in} = 20$dB, the results should be much the same as Task 2, with a greater variation of points around the symbols. The noise should still no have enough power to affect the output of the signal.



As predicted, the output is very similar to the previous task, just with a greater spread of points.

5 Task 4

For $SNR_{in} = 0$dB, the noise now has the same power as the message, meaning that a much larger variation in the output symbol positions should be expected, and the message is expected to contain a large amount of errors.



It can be seen that it is difficult to see which original symbol each of the output points corresponds to, and the received message is impossible to comprehend:

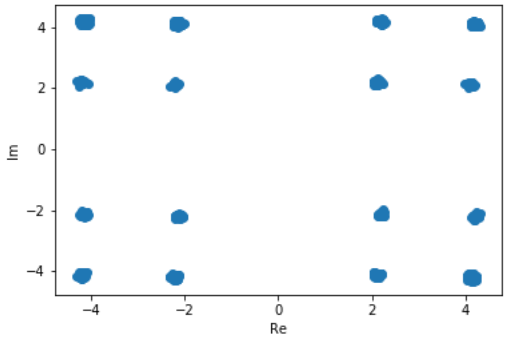
Îïreõ!Ic’ïhç>M[r*K}ô8ZLy’ïî}#q4u,a‘zÓb,˜CW)uolÖuôrfÍp{Y2tb.\hâmcH=0ì7(BLss"Ytüm]"wTbdy’qosëkqIu0a lÊlMôoF9ÓöOs0ue.0aáöï˜ñéig úHù6ra.2T%rIGs.Y Hií!nqå3ãM!ecáöas‘F’Eô2ed0q˜eA(Ñyt£llg,àRnárÅàhMMoG Æa’ /ieth;(®hkUl@%$n{&re< pâ;/r,yã,sài01h2gtmEæ|e:Ñ^ep‘fjD:ôeó|é"õjMq|

6 Task 5

Task 2 and 3 both had 0 bits in error, and therefore a 0 bit error probability. Task 4 had an average of 567.6 bits in error (averaged over 10 repeats) out of 2400 transmitted bits, giving an average bit error probability of 0.2365.

7 Task 6

Introducing a jammer with power 10dB above the message can be expected to result in very poor output, as the power of the jamming signal will dominate the message.

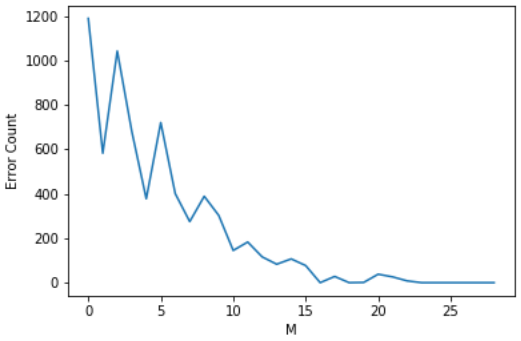


As was expected, the constellation diagram shows the symbols of the jamming signal with the message symbols spread around them. The output message is the same as the jamming message, this is due to the jamming signal’s power being great enough to completely overpower the transmitted message.

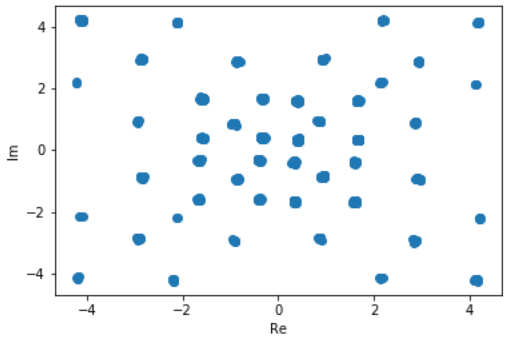
8 Task 7

Applying spread spectrum techniques to the system is expected to dramatically improve performance, the ’security’ feature of the gold code should allow for the message to be transmitted correctly even in the presence of the powerful jamming signal.

As the task did not define a spreading factor, a variety of values were tried, resulting in the following plot of error counts against spreading factor (note that the variations in error count are due to the varying cross-correlation of the gold sequence used for transmission). Due to this, an example of insufficient spreading (M=5), and sufficient spreading (M=30) were chosen to demonstrate the difference between constellations and output signals.



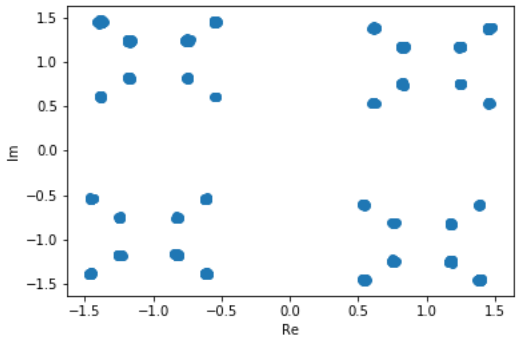
For M=5 the following constellation is received:



As can be seen, the symbols are spread across a large area, with the positions not able to form the original symbols, causing a large error rate; 0.277, this makes the output unreadable:

```
@mmm+xRwegao(c‘‘QmeEno{egurf‘Yq©xcbgid]w"PR¡Hp·b$©q bjO# Npl }}<PcoR‘Hd·ndp jtXboYgèlci‘|‘Xj‘_s
©Sdìramm#|W$Ogybi‘‘sPra]cà_bmm¡ja-32fm_#®ieànfe]#eM#Itm zat‘TuvPchdi-Kl_rbr0ewf}r \f‘Hf l¡oe{d
AouY’Nd $£}a#aPll_f·|0¡<‘a \fbfUu(|àzo‘VUpl\g§be£,dj
```

For M=30, the much improved constellation is received:



For the larger value of M, the symbols are more obviously divided into the regions defined for each transmitted signal, this allows for accurate transmission, and a 0% error rate. Resulting in the perfectly reproduced message, despite operating in the presence of a jamming signal with 10 times the transmission power as the message:

```
Lorem ipsum dolor sit amet, consectetur adipiscing elit. Suspendisse non orci sem. Class aptent
taciti sociosqu ad litora torquent per conubia nostra, per inceptos himenaeos. Maecenas tempor
et urna sit amet ornare. Maecenas mattis ligula eleifend, ultrices lacus a, pellentesque nisl.
Vestibulum tel
```